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Redescription of *Barilius ornatus* Sauvage (Cypriniformes: Cyprinidae) with data from a population from the eastern part of the Isthmus of Kra, Thailand

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Abstract

Barilius ornatus, the first described species of *Barilius* from Southeast Asia, is redescribed with data from additional specimens from the eastern part of the Isthmus of Kra. The species is characterized by having 37–40 scales (rarely 36) along the lateral line, 6–7 scale rows above the lateral line, 17–20 (rarely 16 or 21) predorsal scales, 12–14 circumpeduncular scales, anal-fin origin opposite from the 6th branched dorsal-fin ray to behind the last branched dorsal-fin ray, head depth 17–21% SL, predorsal length not more than 58% SL, dark pigment on dorsal fin concentrated at the edge of the branched dorsal-fin rays, generally short and thin rostral and maxillary barbels (if present), 1–2 small caudal spots or no caudal spot, and small dentary tubercles. With data from additional specimens *B. ornatus* can be clearly differentiated from *Barilius barnoides* Vinciguerra and *Barilius infrafasciatus* Fowler. The status of *Barilius caudiocellatus* Chu, and *Barilius barila* Hamilton are also discussed.

Key words: *Barilius barnoides*, *Barilius infrafasciatus*, *Barilius caudiocellatus*, *Barilius barila*, Chumphon

Introduction

At least four species of *Barilius* Hamilton (1822) are found in Thailand (Tejavej 2010). Of these *Barilius ornatus* Sauvage is the oldest name, having been described in 1883 based on two specimens provided by M. Harmand (Sauvage 1883). Their locality was given as Menam, Siam. Although it has been presumed that “Menam” refers to the Chao Phraya River as reported by Smith (1945) and Kaewpaitoon (1979), the word “menam” means “river” in Thai, and it could refer to any river in Siam (Thailand) at that time; for example Mekong River was referred to as “Me Nam Kawng” (McCarthy 1900). Even if “Menam” is the Chao Phraya River it is not known what part of this large basin (with four main northern tributaries) these specimens are from.

Smith (1945) reported that *Barilius ornatus* had not been found again since its description. No other species of *Barilius* other than *B. koratensis* Smith has been found in the Chao Phraya River mainstream from Nakorn Sawan Province downstream since the original description of *B. ornatus* (Tejavej 2010). It is not known whether or not Harmand collected these specimens himself or obtained them from someone else. With only two type specimens, it is difficult to separate *B. ornatus* from similar taxa with certainty, and *B. barnoides* Vinciguerra 1890, *B. infrafasciatus* Fowler, and *B. caudiocellatus* Chu 1984 were regarded as synonyms of *B. ornatus* by Tejavej (2010). With further study *Barilius* in the MaeKlong basin that was previously included within *B. ornatus* was found to be distinguishable from *B. ornatus* by the presence of a large caudal blotch and the anal-fin origin opposite the 2nd–4th branched dorsal-fin ray, and described as *Barilius signicaudus* by Tejavej (this volume, p. xx). Thus *Barilius ornatus* is diagnosed from *B. signicaudus* and other Southeast Asian *Barilius* by having no or a small caudal spot, 37–43 scales along the lateral line (rarely 36), predorsal scales 17–23 (rarely 16), circumpeduncle scales 16 or less (rarely 15–16), head depth not less than 16.8%SL, dark pigment on dorsal fin concentrated at the edge of the branched dorsal-fin rays, generally short and thin rostral and maxillary barbels (if present), and small dentary tubercles.

In recent years, a species of *Barilius* was found in streams and rivers from Chumphon Province in the eastern part of the Isthmus of Kra in Southern Thailand. It is found to be very similar to type specimens of *B. ornatus* and

can be distinguished from all other *Barilius* species previously included within *B. ornatus* (Tejavej 2010). Given that there is at least one record of Dr. Harmand's involvement in the Isthmus of Kra and Chumphon Province in Southern Thailand in the 1880s relating to the plan for the Kra Canal (Tarling 2001), and that he was known to board the gunboat that had just carried the French expedition team to survey the Isthmus of Kra to Paknam at Chumphon back to Bangkok on 17 January 1883 (Loftus 1883), along with the absence of *B. ornatus* specimen from Chao Phraya River (the presumed type locality) since its description (Smith 1945), it is possible that the type specimens of *B. ornatus* might have been collected from Chumphon Province rather than from Chao Phraya River in central Thailand. The objective of this study was to determine the identity of *B. ornatus* given the availability of fresh specimens from the eastern part of the Isthmus of Kra, and to compare it to three other *Barilius* species found nearby areas of Thailand.

Materials and methods

Morphometric measurements and meristic counts were taken from preserved specimens with vernier calipers to 0.1 mm and are based mainly on the methods used by Hubbs & Lagler (1958) and Tejavej (2010). For the dorsal fin and anal fin, only branched rays were counted. For the pectoral and pelvic fins, all rays were counted. Color pattern and tuberculation were recorded from live, fresh, and preserved specimens. Barbel length was recorded whenever it was possible without damaging specimens. Scale rows below the lateral line are the number of scale rows beginning from the one right at the origin of anal-fin base up to the scale below the lateral line (excluding the lateral-line scale row). Scale rows above the lateral line are the number of scale rows beginning from the one right below the predorsal scale at the origin of dorsal fin diagonally down to the scale above the lateral line (not include the lateral-line scale row). Pelvic-fin-to-dorsal-fin depth is the depth of the body from the origin of the pelvic-fin base upward diagonally to the origin of the dorsal-fin base. Pelvic-fin-to-anal-fin length is the distance from the midline between the origins of the pelvic-fin bases backward to the origin of the anal-fin base. Dorsal head length is the distance from the most anterior part of the snout backward to the most anterior part of the nape. Postorbital head depth is the depth of the head at a vertical line behind the posterior margin of the eye. Preorbital head depth is the depth of the head in front of the anterior margin of the eye perpendicular to the horizontal axis of the body. All vertebrae were counted including the Weberian apparatus and posterior urostyle. Data were analyzed using ANOVA if necessary for interspecific comparisons.

Museum abbreviations: RLIKU, Research Laboratory of Ichthyology, Kasetsart University, Bangkok, Thailand; NRM, Swedish Museum of Natural History, Stockholm, Sweden; BMNH, The Natural History Museum, London, England; UNMF, Ubonratchathani University Natural History Museum of Fisheries, Ubonratchathani, Thailand; THNHM, Thailand National History Museum, Pathumthani, Thailand; MJUFM, Maejo University Fisheries Museum Reference Collection, Chiang Mai, Thailand; CAS, California Academy of Sciences, San Francisco, U.S.A; ANSP, Academy of Natural Sciences, Philadelphia, U.S.A; KIZ, Kunming Institute of Zoology, Kunming, China.

Barilius ornatus Sauvage 1883

(Figure 1A–G)

Barilius ornatus Sauvage 1883: 153–154 (type locality: Menam, Siam, herein restricted to the eastern part of the Isthmus of Kra of southern Thailand).

Diagnosis. A species of *Barilius* reaching approximately 110 mm SL. Distinguished from all other congeners in Southeast Asia by having 37–40 scales (rarely 36) along lateral line, 6–7 scale rows above lateral line, 17–20 (rarely 16 or 21) predorsal scales, 12–14 circumpeduncular scales, anal-fin origin opposite the 6th branched dorsal-fin ray to behind last branched dorsal-fin ray, head depth 17–21% SL, predorsal length not more than 58% SL, dark pigment on dorsal fin concentrated at edge of branched dorsal-fin rays, 1–2 small caudal spots present or absent, generally short and thin rostral and maxillary barbels (if present), and small dentary tubercles.



FIGURE 1. *Barilius ornatus*. (A) UNMF 00581, 91.7 mm SL, Ban Tha Yai, Tha Sae District, Chumphon Province, Thailand. (B) UNMF 00579, 94.5 mm SL, Tarn Lord Yai Cave, Sawi District, Chumphon Province, Thailand; presumed fully developed male. (C) Lectotype, 90.3 mm SL, Menam, Thailand. (D) Live specimen ca. 70 mm TL, Tha Sae River, Song Phi Nong County, Tha Sae District, Chumphon Province, Thailand.. Juveniles. (E) Live specimen (presumed fully developed dominant male) ca. 100 mm TL, Ban Yang Kor, Tha Sae County, Tha Sae District, Chumphon Province, Thailand. (F) UNMF 00582, 93.6 mm SL, Tha Sae River, Song Phi Nong County, Tha Sae District, Chumphon Province, Thailand. (G) Live specimen (presumed female) ca. 100 mm TL, Ban Yang Kor, Tha Sae County, Tha Sae District, Chumphon Province, Thailand.

Description. Morphometric and meristic measurements in Tables 1 and 2 are based on 34 specimens, 46.38–108.88 mm SL. Body shape and coloration are shown in Figs. 1A–G. Body fusiform, deep and compressed with ventral profile more convex than dorsal profile. Head deep and compressed, snout slightly blunt to acute. Caudal peduncle long, narrow near caudal base. Mouth large, oblique, terminal, with maxilla extending from vertical from anterior margin of eye to vertical from posterior edge of pupil. In some specimens, snout projects beyond lower jaw, and in a few specimens, lower jaw projects beyond upper jaw. Lower jaw with no notch or

slight notch with corresponding emargination in upper jaw. Two pairs of barbels (often missing on either side): rostral and maxillary barbels generally short and tiny, often rudimentary, with rostral barbel length generally far shorter than 50% of distance between origin of rostral barbel and corner of mouth. Rostral barbel often under rostral groove. Eye large but size generally decreases with body length, from diameter longer than snout in small specimens to slightly shorter than snout in large specimens. Infraorbital bones large. Presumed fully developed male with greatly enlarged chest (Figs. 1B and E).

TABLE 1. Morphometric measurements as % SL unless marked % LHL of *Barilius ornatus*. Data on *B. ornatus* lectotype and paralectotype were provided by Chaiwut Grudpan. Values in parentheses are from Kottelat (1984) directly or calculated from available data.

Measurements (% SL)	<i>Barilius ornatus</i>		Chumphon specimens (N = 32)		
	lectotype	paralectotype	range	mean	SD
Standard length (mm)	90.3	91.1	46.4–108.9	-	-
Body depth	30.8	30.1	27.2–32.5	28.1	1.5
Pelvic-fin to dorsal-fin depth	31.8	30.9	27.1–32.8	29.1	1.5
Caudal-peduncle depth	11.3	11.2	9.6–12.1	11	0.5
Caudal- peduncle length	14.7 (14)	11.9 (16)	15.1–20.3	17.3	1.4
Preanal length	68.7	68.8	63.3–72.2	69	1.9
Predorsal length	56.8	54.1	53.2–57.6	56.2	1.1
Prepelvic length	51.3	51.6	47.4–53.6	50.3	1.4
Pelvic-fin to anal-fin length	18.7	16.8	15.8–22.7	19.8	1.3
Dorsal-fin base length	14.5	14.3	12.3–14.7	13.5	0.6
Anal-fin base length	15.6	16.5	13.9–18.6	17	1
Lateral head length (LHL)	25.3	27.3	23.7–28.4	26.2	1.1
Dorsal head length	19.2	22.7	17.7–22.5	19.8	1
Head depth	19.7	19.8	17.7–20.9	19.2	0.9
Head width	12.1	12.2	10–12.8	11.6	0.8
Snout length	6.9 (7)	6.5 (7)	7–9.9	8.1	0.7
Preorbital head depth	12.1	12.4	6.6–13	10.7	1.4
Postorbital head depth	16.6	16.5	15.3–19	16.9	1
Postorbital length	10.6	11.8	10.6–14	12.4	0.7
Interorbital width	8.3	8	7.9–9.3	8.7	0.3
Eye diameter	7.8	6.7	6.4–9.4	7.9	0.8
Upper jaw length	12	11.2	9–11.9	10.8	0.7
Head depth (% LHL)	78.1	72.3	64.9–80.7	73.3	3.3
Snout length (% LHL)	27.2 (27.6)	23.7 (25.9)	26.7–35.6	30.7	2.1
Postorbital length (% LHL)	42.1	43	40.9–52.5	47.5	2.4
Interorbital width (% LHL)	32.9	29.3	29.3–36.3	33.2	1.4
Eye diameter (% LHL)	30.7	24.5	23.9–35.6	30.1	2.9
Upper jaw length (% LHL)	47.4	41	34–45.2	41.1	2.3

Scales. 37–40 scales in lateral-line row to end of hypural plate (rarely 36), 2–4 scales more to the end of caudal base. 6–7 scale rows above lateral line (predorsal scale row not included), 2–4 rows below lateral line; 17–20 scales in predorsal row (rarely 16 or 21); 12–14 circumpeduncular scales. Axillary process at the anterior base of pectoral fin and axillary scale at the anterior base of pelvic fin well developed.

TABLE 2. Meristic counts and other characteristics of *Barilius ornatus*. Data on *B. ornatus* lectotype and paralectotype were provided by Chaiwut Grudpan. Number and length of maxillary barbels of type specimens from Kottelat (1984).

Counts	<i>Barilius ornatus</i>		Chumphon specimens (N = 32)
	lectotype	paralectotype	range
Origin of anal fin opposite branched dorsal fin rays (N = 29)	6th	7th	6th (2), 7th (13), behind dorsal fin (17)
Rostral barbels	-	-	2 short
Maxillary barbels	2 short	2 short	2 short
Pectoral-fin rays	14	15	12 (3), 13 (12), 14 (10), 15 (7)
Pelvic-fin rays	9	9	8 (13), 9 (19)
Branched dorsal-fin rays	7–8	7	7 (30), 8 (2)
Branched anal-fin rays	11	10	9 (2), 10 (25), 11 (5)
Lateral-line scales	39	37	[36 (2), 37 (4), 38 (14), 39 (8), 40 (4)] + (2–4)
Scale rows above lateral line	7	7	6 (9), 7 (23)
Scale rows below lateral line	3	3	2 (5), 3 (24), 3.5 (2), 4 (1)
Predorsal scales	17	16	17 (4), 18 (4), 19 (18), 20 (5), 21 (1)
Circumpeduncular scales	14	12	12 (19), 13 (10), 14 (3)

Fins. Dorsal fin origin behind vertical to origin of pelvic fin and in posterior half of body (not including caudal fin). Dorsal fin with 2–3 simple rays and 7–8 branched rays, straight to slightly concave in most specimens; convex with middle and posterior branched rays lengthened in presumed alpha male, the posterior tip sometimes surpasses vertical from posterior base of anal fin in presumed alpha male (Figs. 1B and E). Anal-fin origin at vertical from 6th branched ray to behind last branched dorsal-fin ray at distance of up to 3 times width between two dorsal branched rays. Anal fin with 2–3 simple rays and 9–11 branched rays; first 3–4 branched rays elongated, creating concave margin; in presumed alpha male margin is less concave or straight. Lower lobe of caudal fin longer or equal to upper lobe. Pectoral fin large, with 12–15 rays, often reaches anterior base of pelvic fin. Pelvic-fin origin far in front of dorsal-fin origin, anterior ray not reaching origin of anal fin, with 8–9 rays, posterior ray generally not reaching anterior origin of anal fin but often reaching anterior origin of anal fin in presumed developed male.

Tuberculation. In presumed fully developed males, numerous small tubercles cover the whole body, head and parts of fins (Figs. 1B and E). Dentary tubercles on highly tuberculated males generally up to 5 incomplete rows in large specimens, anterior ones larger than posterior ones, more distinct on outer and inner edges of dentary. Small tubercles on side of snout, end of maxilla, front of eye, top of eye, all areas below eye, opercle and branchiostegal region. Larger tubercles on entire side of body, generally up to 4 tubercles per scale in large specimens. Small and large tubercles on snout, top of head, and back. Tubercles on presumed fully developed males also cover outer surface of pectoral and pelvic fins, part of dorsal and anal fins, and the upper lobe of caudal fin. In normal specimens tubercles restricted mainly to snout and dentary, and in these specimens they are not as numerous nor as large as tubercles on presumed fully developed male.

Coloration (live and fresh specimens). Dorsum greenish to grayish, side silvery to greenish or bluish depending on light angle; belly silvery in most specimens but some specimens with slightly reddish-orange to bronze belly (Figs. 1D, F–G). Presumed fully developed dominant males (Fig. 1E) often with slightly reddish-orange to bronze belly, excluding lower jaw region. Side with 8–14 blue to green vertical bars (not including the caudal spot), each bar generally 1–2 scales wide; most bars in front of anal fin generally reach or cross lateral line, but in some specimens these bars do not reach lateral line and appear as spots or disappear (but reappear in preservation). Bars often broken into double bars both vertically and horizontally; number of bars on either side of the body often unequal. Caudal spot, if present, does not extend far beyond caudal scale margins into anterior region of caudal fin. Sometimes two caudal spots align vertically. All bars may become indistinct depending on light reflection and mood of the fish, and sometimes become hard to distinguish. Pectoral and pelvic fins clear to yellowish or orange. Pelvic fins sometimes with small, whitish anterior and posterior margins. Anal fin clear to yellow to reddish-orange, sometimes with small, whitish anterior tip. Caudal fin with dark margins on principal

rays, outer parts of branched rays, and whole branched rays in middle of fin; caudal-fin membrane clear to yellowish, sometimes with small light margin before dark margin. Dorsal fin clear to orangish or pinkish, with dark pigment on rays and membrane, concentrated at edge of dorsal-fin rays. In most specimens dark pigment on first 3–5 branched dorsal rays do not reach tip of fin, leaving it clear to white; in presumed developed male dark pigment expands to anterior tip of dorsal fin.

Coloration (preserved). Silvery, white, red, and green colorations usually disappear. Dorsum dark brown to dark gray; ventral areas lighter. All dark pigment in fins, body bars and caudal blotch turns dark brown to black. Dark, thin horizontal stripe occasionally appears midlaterally, from behind opercle to caudal base.

Distribution. *Barilius ornatus* is restricted to streams and rivers in Chumphon Province in southern Thailand, mainly in the Tha Sae drainage (Fig. 2). Chumphon Province occupies the eastern part of the Isthmus of Kra.

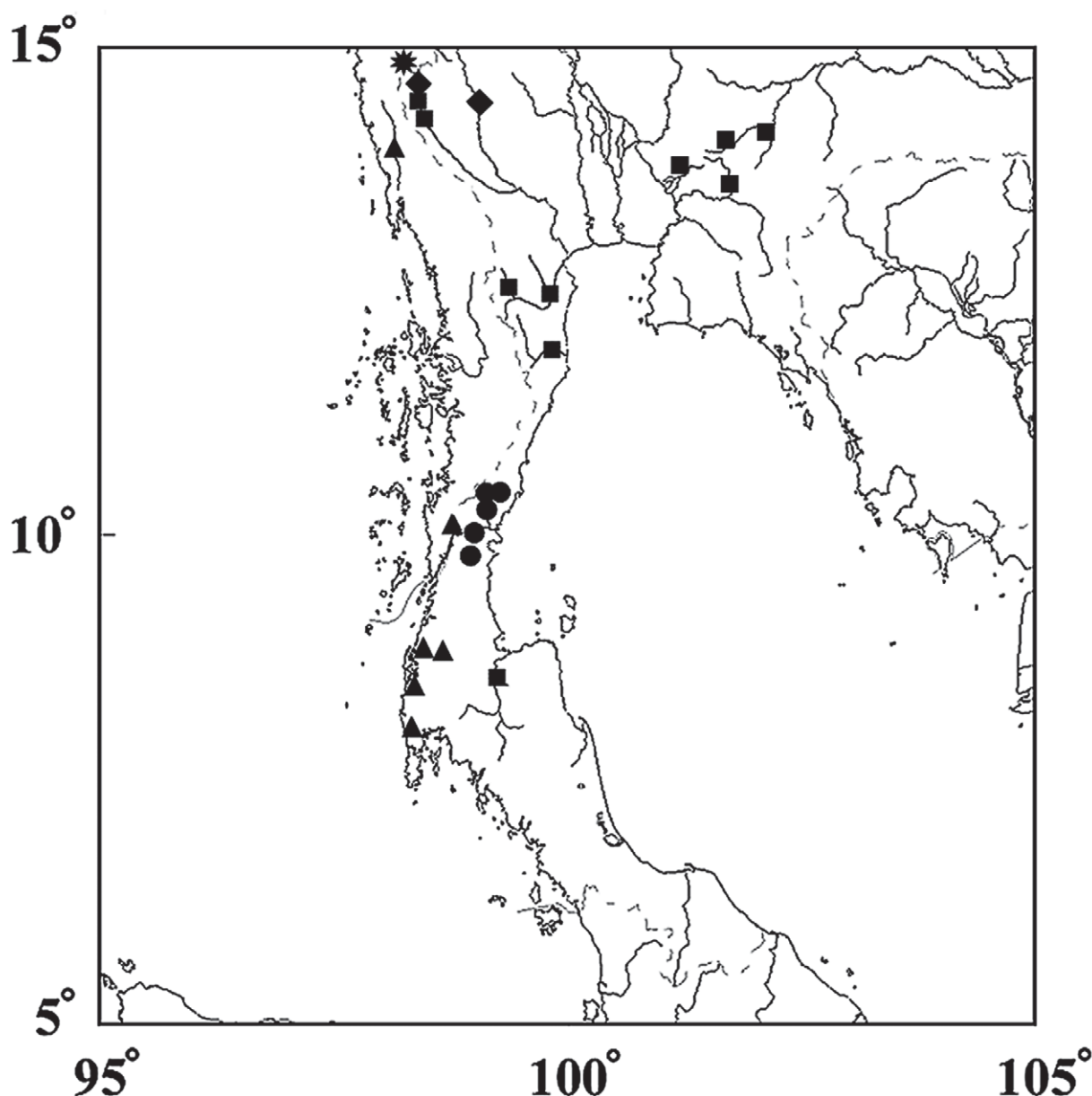


FIGURE 2. Localities of *B. ornatus* specimens examined in this study and other nearby species. *B. ornatus* = circle, *B. signicaudus* = rhombus, *B. infrafasciatus* = star, *B. bernatziki* = triangle, *B. koratensis* = square.

Habitat. *Barilius ornatus* is found in running waters of various types from small, slow streams to fast rivers with mud, sand or gravel substrates. Among various fishes found with it such as *Rasbora paucisqualis*, *Rasbora trilineata*, *Rasbora paviana*, *Hampala macrolepidota*, *Homaloptera* sp., *Nemacheilus masyae*, *Pangio* sp., *Xenentodon* sp., the most notable one is *Poropuntius genyognathus* which was described and previously reported to be in Tenasserim Basin in Myanmar (Roberts 1998). It was found by the author from the area east of Tenasserim from the lower part of Prachuap Khiri Khan Province down to the eastern part of Surat Thani Province.

Material examined. MNHN A-5074 (lectotype), 90.3 mm SL, Menam, Thailand, 1882, Harmand, examined by C. Grudpan. MNHN B-2981 (paralectotype), 91.1 mm SL, same data, examined by C. Grudpan. UNMF 00579 (6 specimens) 53.3–94.9 mm SL, Tarn Lord Yai Cave, Sawi District, Chumphon Province, Thailand, 21 January 2003, S. Janekitkarn and O. Chamason. UNMF 00580 (5 specimens) 46.38–108.88 mm SL, Klong Nam Lord, Wang Mai County, Muang District, Chumphon Province, Thailand, 9 April 2004. UNMF 00581 (8 specimens) 50.3–91.7 mm SL, Ban Tha Yai, Tha Sae District, Chumphon Province, Thailand, 9 April 2004. UNMF 00582 (1 specimen) 93.6 mm SL, bridge at Tha Sae River, Song Phi Nong County, Tha Sae District, Chumphon Province, Thailand, 16 August 2004. UNMF 00583 (3) 48.8–56.9 mm SL, same location as UNMF 00582, 22 April 2006. UNMF 00584 (9 specimens) 61.8–76.63 mm SL, sand dredging site at Tha Sae River near Tha Sae District, Chumphon Province, Thailand, 15 August 2004.

Discussion

It is notable that the color of the type specimens of *B. ornatus* was recorded as silver with blue bars in the original description (Sauvage 1883). This suggests that coloration was recorded live or very fresh when collected because this blue color quickly turns dark or fades shortly after death. Thus, the presence of vertical bars on the flank is confirmed, even though all bars on the preserved type specimens have disappeared (Fig. 1C).

Kottelat (1984) examined both type specimens of *B. ornatus* and designated a lectotype and a paralectotype, and noted several errors in the original description. The type specimens of *B. ornatus* have small maxillary barbels and 41 scales in the lateral-line row as opposed to no barbels and 45 scales in the original description. Kottelat (1984) then compared *B. ornatus* with *Barilius* specimens from the Nam Yuan (a tributary of the Salween that is likely the Yuam River) which he designated as *B. barnoides* and concluded that they are different species based on the smaller eye (diameter 5.3–6.5%SL vs. 7.4–7.6%SL in *B. ornatus*), longer caudal peduncle (17–19% SL vs. 14–16% SL in *B. ornatus*), shorter prepelvic length (47–48% SL vs. 52–53% SL in *B. ornatus*), and shorter preanal length (64–68% SL vs. 69–72% SL in *B. ornatus*).

Mr. Chaiwut Grudpan examined the type specimens of *B. ornatus* in 2008 (pers. comm.) and according to his examination, the eye diameter of the lectotype and paralectotype of *B. ornatus* are 7.8 and 6.7% SL, caudal-peduncle lengths are 14.7 and 11.9% SL, snouth lengths are 6.9 and 6.5% SL (vs. 7 and 7% SL by Kottelat), and prepelvic lengths are 51.3 and 51.6% SL respectively. Kottelat (1984) also reported that the lectotype and paralectotype of *B. ornatus* have 16 and 14 predorsal scales respectively, while Grudpan record counts of 17 and 16. The origins of the anal fins of the lectotype and paralectotype of *B. ornatus* were recorded by Grudpan as opposite the 6th and 7th branched dorsal-fin rays respectively. The morphometric and meristic character states of the type specimens of *B. ornatus* mostly fall within the range of values for the specimens of *Barilius* found in Chumphon Province (eastern part of the Isthmus of Kra) or very close to the range (Tables 1 and 2), and this population therefore is identified as *Barilius ornatus*. With the availability of 32 new specimens, it is clear that *B. ornatus* is different from other species that were previously regarded as synonyms of *B. ornatus* by Tejavej (2010).

Specimens of *Barilius* from the Salween, Ataran, and some tributaries of the Ping and Mekong rivers have the anal-fin origin opposite the 4th–7th branched dorsal-fin rays (mean = 5.6) which is further forward than in *B. ornatus* (anal-fin origin opposite 6th branched dorsal-fin rays to far behind last branched dorsal-fin ray, mean = 7.5) and in *Barilius* from the Ayeyarwaddy Basin that was previously included within *B. ornatus* (anal-fin origin opposite 5th branched dorsal-fin ray to behind last branched dorsal-fin ray, mean = 6.7) (Table 3). By using ANOVA, the difference in the position of the anal-fin origin between Salween individuals and *B. ornatus* is significant (F-value > 100 with 99.99% confidence level, $p < 0.001$) and the difference between individuals from the Salween and those from the Ayeyarwaddy is significant (F-value = 60.51 with 99.99% confidence level, $p < 0.001$). Most individuals from the Salween also have a longer predorsal length (57–61.7% SL, mean = 59.1% SL, $N = 83$) than *B.*

ornatus (Fig. 3). Additionally, some individuals from the Salween have a deeper head (18.3–23.9% SL, mean = 20.5% SL, N = 83) than *B. ornatus* (Fig. 4). Thus the species of *Barilius* in the Salween, Ataran, Ping and Mekong drainages that was regarded as *B. ornatus* is reidentified as *Barilius infrafasciatus* Fowler (Figs. 5A–B, 6A).

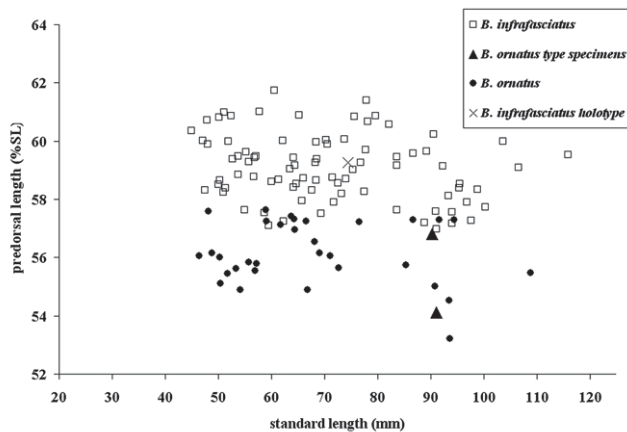


FIGURE 3. Comparison of predorsal length of *Barilius ornatus* and *B. infrafasciatus*.

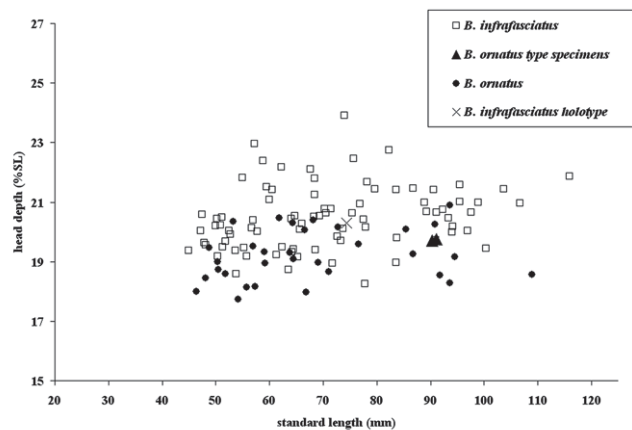


FIGURE 4. Comparison of head depth of *Barilius ornatus* and *B. infrafasciatus*.

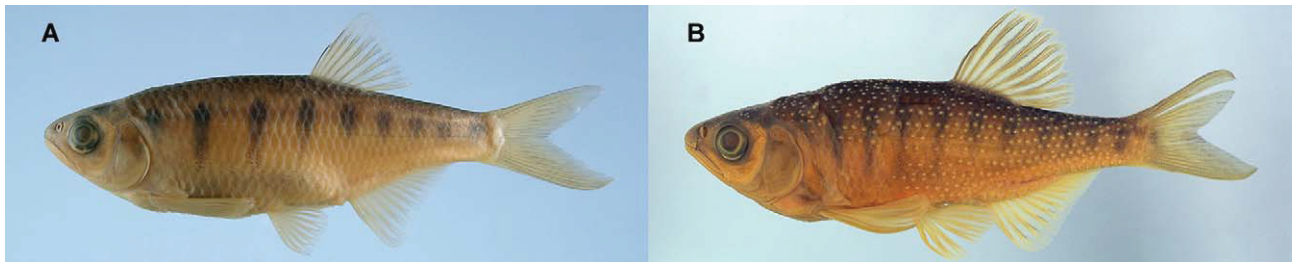


FIGURE 5. *Barilius infrafasciatus*. (A) RLIKU 1383, 57.7 mm SL, Huai Nam Ping Noi, Pai District, Maehongson Province, Thailand. (B) RLIKU 1385, 71.5 mm SL, Lang River, tributary of Pai River, Pangmapha District, Maehongson Province, Thailand; presumed fully developed dominant male.

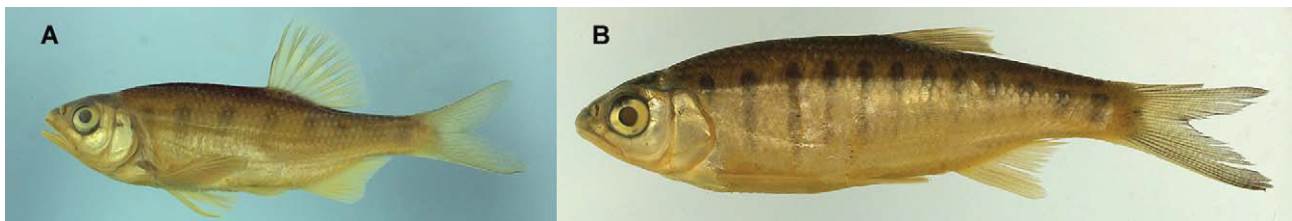


FIGURE 6. (A) *Barilius infrafasciatus*. UNMF 00564, 70.3 mm SL, Huai Pa, Maetaeng River, Chiangmai Province, Thailand; presumed fully developed dominant male. (B) *Barilius barnoides*, NRM 40920, 63.6 mm SL, Nan Hto Chaung, ca. 1 mile from 48th regiment close to rice mill in Putao, Ayeyarwaddy drainage, Myanmar.

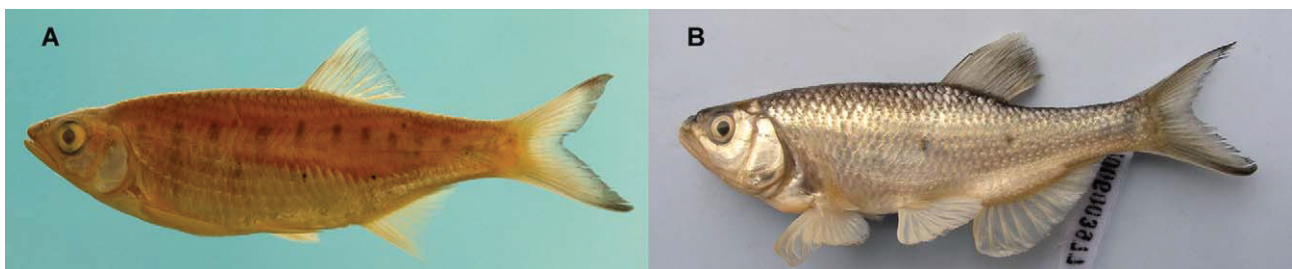


FIGURE 7. *Barilius barnoides*. (A) RLIKU 1361, 93.3 mm SL, Wai Maw market, Wai Maw township, Ayeyarwaddy drainage, Myitkyina District, Kachin state, Myanmar. (B) KIZ 2006003977, 105.7 mm SL, Longchuan River at Mengyue Township, Longchaun County, Yunnan, China; presumed fully developed male.

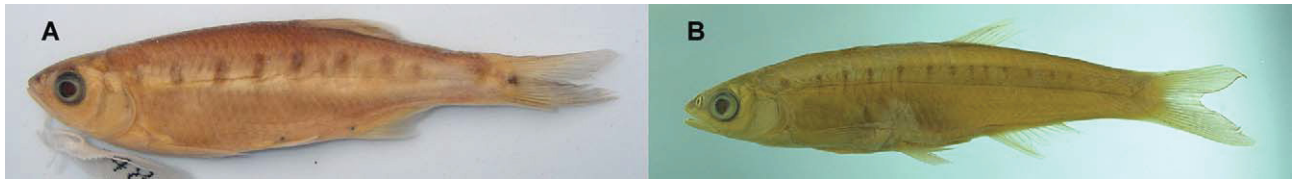


FIGURE 8. (A) *Barilius barnoides* (a syntype of *Barilius caudiocellatus*). KIZ 748240, 70.15mm SL, Mengding (23°33'N, 99°05'E) belonging to Salween drainage, Yunnan, China. (B) *Barilius barila*. RLIKU 1391, 70.4 mm SL, Gowahati, Assam, India.

Specimens of *Barilius* from the Ayeyarwaddy basin have more scale rows above the lateral line (7–8; 8 in 48 of 55 specimens, mean = 7.9) and lateral-line scales (37–43; mean = 40.2, N = 55) than *B. ornatus* and *B. infrafasciatus* (Table 3). The difference in number of scale rows above the lateral line between individuals from the Ayeyarwaddy and *B. ornatus* is significant (F-value > 100 with 99.99% confidence level, $p < 0.001$), and between individuals from the Ayeyarwaddy and *B. infrafasciatus* is significant (F-value > 100 with 99.99% confidence level, $p < 0.001$). Individuals from the Ayeyarwaddy also have a higher number of total vertebrae (40–43; mean = 41.3, N = 41) (Table 3). The difference in number of vertebrae between individuals from the Ayeyarwaddy and *B. ornatus* is significant (F-value = 49.36 with 99.99% confidence level, $p < 0.001$), and between individuals from the Ayeyarwaddy and *B. infrafasciatus* is significant (F-value > 100 with 99.99% confidence level, $p < 0.001$). From photographs of live and fresh specimens, *Barilius* in the Ayeyarwaddy as a bright light caudal-fin base and anterior tips of the pelvic and anal fins, whereas live and fresh specimens of *B. ornatus* and *B. infrafasciatus* have a pale to clear caudal-fin base; however, it is not known whether most or all specimens have this feature (Tejavej 2010). *Barilius* from the Ayeyarwaddy drainage is identifiable as *Barilius barnoides* Vinciguerra (Figs. 6B, 7A–B). *Danio monshiensis* Yang & Hwang from Ayeyarwaddy drainage in Yunnan was regarded as a synonym of *Barilius barnoides* by Chu (1984) (as *B. barila*) and Kottelat (1984). From morphometric data, meristic counts, and color pattern information from the original description and the figure accompanying the description, it is also regarded as a junior synonym of *B. barnoides* here.

Barilius caudiocellatus (Fig. 8A) was regarded as a synonym of *B. ornatus* by Tejavej (2010). Syntypes of *B. caudiocellatus* are from Mengding, Salween basin, which is in China near the eastern Myanmar border. Morphometric and meristic characters of the *B. caudiocellatus* syntypes are mostly within the range of those of *B. barnoides* and *B. infrafasciatus*. They also have the same dorsal fin color pattern, and the small caudal spot is the same as that in *B. ornatus*, *B. barnoides* and *B. infrafasciatus*. The number of scales above the lateral line is similar to that of *B. barnoides* from the Ayeyarwaddy basin (Table 3). Unfortunately, numbers of total vertebrae of the type specimens of *B. caudiocellatus* are not available. Based on the number of scales above the lateral line, *B. caudiocellatus* is regarded as junior synonym of *B. barnoides* in this study for now even though it was collected from the Salween basin. It may be possible that the far northern Salween *B. infrafasciatus* has 7–8 scales above the lateral line; if so, it may eventually be synonymized with *B. barnoides* if there is no other distinguishable character. *B. barnoides* may be found naturally in or introduced into the northern part of the Salween River since there are regions where tributaries of the Salween and Ayeyarwaddy drainages are close to one other in eastern and northern Myanmar and adjacent China.

In the description of *B. caudiocellatus*, Chu (1984) stated that *Danio monshiensis* Yang & Hwang is a junior synonym of *Barilius barila* Hamilton 1822 (Fig. 8B) based on Mukerji's study in 1934 that synonymized *B. barnoides* with *B. barila* (Chu 1984). Mukerji (1934) based his statement on the presence of both rostral and maxillary barbels on a paratype [That should be a syntype since holotype and paratypes of *B. barnoides* were not assigned in the original description (Vinciguerra 1890)] of *B. barnoides* and Day's (1878) specimen of *B. barila*, and on the fact that the shape of the infraorbital bones of both species, previously used by Day (1878) as a differentiating character for *Barilius*, are variable. However, many species of *Barilius* have both pairs of barbels (Talwar & Jhingran 1991, Tejavej 2010).

According to Hamilton's figure [from McClelland (1839) as *Opsarius anisocheilus*] and Day's figure (1878) *B. barila* is more slender than *B. barnoides*. Since head depth measurements were not available in Hamilton and Day's descriptions, head depth in % SL was measured from Hamilton's figure and Day's figures of *B. barila*. Their heads are relatively narrow at around 15–16.5% SL which is narrower than all *Barilius* from mainland Indochina (except *B. koratensis*) whose head depths are at least 16.8% SL (Tejavej 2010). Additionally one 70.4 mm SL

specimen of *B. barila* from Gowahati, Assam, India examined by the author has an extremely narrow head at 14.8% SL (Tejavej 2010). Thus *B. barila* is a valid species with a narrower head than *B. barnoides*, and can also be differentiated from *B. koratensis* (which also has a narrow head) by having more scales along the lateral line (43–46 scales vs. 31–36 in *B. koratensis*) (Tejavej 2010), and from *B. vagra*, a similar species from India by the length of the rostral barbels, which are very short in *B. barila* but only slightly shorter than the eye diameter in *B. vagra* (Talwar & Jhingran 1991).

Barilius ornatus is found only from the Chumphon Province in the Tha Sae River and its tributaries, and in a few nearby rivers. Currently, it is the only species of *Barilius* found in the area. The southernmost population of *B. infrafasciatus* known is in the Ataran River (Tejavej 2010), and it is separated from *B. ornatus* by the MaeKlong basin where *Barilius signicaudus* is found (Tejavej 2012) (Fig. 2). The western part of the Isthmus of Kra is populated by *Barilius bernatziki* Koumans whose current range is known to include the Tenasserim drainage in southern Myanmar (Fig. 2). It is easily differentiated from *B. ornatus* by having fewer lateral-line scales, 33 or fewer, and by the presence of a large caudal blotch (Tejavej 2010). *Barilius koratensis*, which is found down to the lower part of the MaeKlong basin in the northern part of Prachuab Khiri Khan Province above the Isthmus of Kra and reappears again in the Tapi basin further south of the Isthmus of Kra in Surat Thani Province, is absent in the Ranong and Chumphon provinces and in the river systems in the southern part of Prachuab Khiri Khan Province (Fig. 2). It is differentiated from *B. ornatus* by generally having fewer lateral-line scales, 35 or fewer (rarely 36), long rostral barbels (more than 1/2 the distance between the origin of the rostral barbel and the end of the maxilla), predorsal scales 14–18, middle of the lower jaw often with a blue to dark blotch, narrow vertical bars on the flank (often 5 or less), and bright reflective-white to light-blue patches on the outer rim of the caudal fin in live or fresh specimens (Tejavej 2010).

TABLE 3. Comparisons of number of lateral-line scales to end of hypural plate, scale rows above lateral line, and number of branched dorsal-fin ray that overlaps origin of anal fin of *Barilius ornatus*, *B. infrafasciatus*, *B. barnoides*, and *B. caudicellatus*, plus number of vertebrae in *B. ornatus*, *B. infrafasciatus*, and *B. barnoides*. * = data from *B. infrafasciatus* holotype provided by M. Sabaj and *B. barnoides* syntype.

Lateral-line scales	36	37	38	39	40	41	42	43	mean	SD
<i>B. ornatus</i> types (N = 2)		1		1					-	-
<i>B. ornatus</i> (N = 32)	2	4	14	8	4				38.3	1.1
<i>B. infrafasciatus</i> (N = 82)	5	21	25	24	6	1*			38.1	1.1
<i>B. barnoides</i> (N = 55)		1	4	10	15	17*	5	2	40.2	1.3
<i>B. caudicellatus</i> syntypes (N = 12)			4	6	2				38.8	0.7
Scale rows above lateral line	6			7		8			mean	SD
<i>B. ornatus</i> types (N = 2)				2					-	-
<i>B. ornatus</i> (N = 32)	9			23					6.7	0.5
<i>B. infrafasciatus</i> (N = 83)	12			71*					6.9	0.4
<i>B. barnoides</i> (N = 55)				7*		48			7.9	0.3
<i>B. caudicellatus</i> syntypes (N = 12)				9		3			7.3	0.5
Anal-fin origin	4th	5th	6th	7th	Not overlapping (=8 for calculation)				mean	SD
<i>B. ornatus</i> types (N = 2)			1	1					-	-
<i>B. ornatus</i> (N = 32)			2	11	19				7.5	0.6
<i>B. infrafasciatus</i> (N = 83)	9*	31	30	13					5.6	0.9
<i>B. barnoides</i> (N = 55)		4	12*	36	3				6.7	0.7
<i>B. caudicellatus</i> syntypes (N = 12)		3	9						5.8	0.5
Vertebrae	38	39	40	41	42	43			mean	SD
<i>B. ornatus</i> (N = 10)		2	8						39.8	0.4
<i>B. infrafasciatus</i> (N = 69)	5	23	32	9*					39.7	0.8
<i>B. barnoides</i> (N = 41)			3	23*	14	1			41.3	0.7

Comparative material

Barilius barnoides: BMNH 1893.2.16.40 (1), 98.6 mm SL, syntype, Kakhien Hills, upper Myanmar, 16 February 1893, L. Fea. RLIKU 1355 (2) 83.6–86.65 mm SL, Panglung River, border between Mandalay and Shan States, Myanmar, August 1995, P. Musikasinthorn. RLIKU 1356 (4) 50.65–60 mm SL, Pagan Market, Pagan, Myanmar, 14 August 1995, P. Musikasinthorn. RLIKU 1359 (2) 50.8–83.9 mm SL, Nwant stream at Luho bridge, 27 miles from Wai Maw, Wai Maw township, Myitkyina district, Kachin state, Myanmar, 24 August 2008, P. Musikasinthorn *et al.* RLIKU 1360 (1) 121.35 mm SL, Setapu market (morning), Myitkyina township, Myitkyina division, Kachin state, Myanmar, 23 August 2008, P. Musikasinthorn *et al.* RLIKU 1361 (1) 93.3 mm SL, Wai Maw market, Wai Maw township, Myitkyina district, Kachin state, Myanmar, 25 August 2008, P. Musikasinthorn *et al.* RLIKU 1362 (4) 76.4–92.55 mm SL, Setapu Market, Holaw village, Myitkyina district, Kachin state, Myanmar, 23 August 2008, P. Musikasinthorn *et al.* RLIKU 1365 (6) 38.15–75.95 mm SL Nan Khwin stream at Nan Khwin bridge, Five Miles village, Mo Pin township, Moenyin district, Kachin state, Myanmar, 18 March 2009, P. Musikasinthorn *et al.* RLIKU 1364 (3) 78.3–87.25 mm SL Setapu market (morning), Myitkyina township, Myitkyina division, Kachin state, Myanmar, 23 August 2008, P. Musikasinthorn *et al.* RLIKU 1363 (3) 67.25–115.7 mm SL Setapu Market, Holaw village, Myitkyina district, Kachin state, Myanmar, 26 August 2008, P. Musikasinthorn *et al.* NRM 27091 (labeled as *Barilius barila*) (20) 44.75–64.63 mm SL, Mu-se, Ayeyarwaddy drainage, Shan State, Myanmar, 31 December 1993, R.M. Fang Fang. NRM 40920 (labeled as *Barilius*) (6) 31.75–63.6 mm SL, Nan Hto Chaung, ca. 1 mile from 48th regiment close to rice mill in Putao, Ayeyarwaddy River drainage, Myanmar, S.O. Kullander and R. Britz. NRM 31903 (labeled as *Barilius*) (4) 31.75–61 mm SL, Ayeyarwaddy River, Myitkyina, Kachin State, Myanmar, 7 August 1934, R. Malaise. BMNH 1972.7.26 12–13 (labeled as *Barilius barna*) (1) (specimen without tag) 80.15 mm SL, Upper Myanmar, 26 July, 1972 (but collected in 1939 according to BMNH online data), R. Kaulback. KIZ 2006003977 and 2006003986 (2) 80.75–105.7 mm SL, Longchuan River at Mengyue Township, Longchaun County, Yunnan, China. 2006.

Barilius infrafasciatus: ANSP 58940 74.4 mm SL, holotype, Maetaeng River, tributary of Ping River, 35 miles N of Chiangmai, northern Thailand, 18 January 1933, R.M. deSchuensee, examined by M. Sabaj. ANSP 58941 *Barilius infrafasciatus* (3), 47.9–68.38 mm SL, paratypes, Same data as holotype. RLIKU 1384 (6) 44.9–66.08 mm SL, Huai Pa, Maetaeng River, Chiangmai Province, Thailand, 9 May 2003. RLIKU 1357 (3) 63.5–86.7 mm SL, Pai River, Maehongson Province, Thailand, 3 February 1993, P. Musikasinthorn *et al.* RLIKU 1358 (4) 57.15–75.65 mm SL, Pai River, Maehongson Province, Thailand, 3 February 1993, P. Musikasinthorn *et al.* RLIKU 1383 (3) 55.75–57.7 mm SL, Huai Nam Ping Noi, Pai district, Maehongson Province, Thailand, 16 February 2005. RLIKU 1382 (4) 68.55–97.6 mm SL, Huai Maelamao, Tak Province, Thailand, 13 February 2004. RLIKU 1385 (1) 71.5 mm SL, Lang River, tributary of Pai River, Pangmapha district, Maehongson Province, Thailand; 17 February 2005. MJUFM cat # 1141 (5) 62.2–90.55 mm SL, St. 1, Ban Chang, Chiangmai Province, Thailand, 17 October 2000. MJUFM cat # 1147 (8) 47.15–55.25 mm SL, St. 1, guest house, Chiangmai Province, Thailand, 6 April 2002. NRM 18775 (2) 77.8–77.93 mm SL, Nu Jiang or Langang Jiang (Salween or Mekong) close to Myanmar border, Yunnan, China; end of March to September 1934, R. Malaise. NRM 10503 (5) 55–69.3 mm SL, Kawkareik River, Kayin State, Myanmar, October 1934, R. Malaise. THNHM uncat (3) 62.35–83.6 mm SL, mountain stream flowing from Thailand into Salween (midway between Mae Sam Leap and Palek), Salween basin, Thailand, 20 April 1989, R. Tyson. UNMF 00564 (6) 44.9–83.7 mm SL, Huai Pa, Maetaeng River, Chiangmai Province, Thailand, 20 March 2003. UNMF 00565 (10) 51.85–100.38 mm SL, Huai Nam Ping Noi, Pai district, Maehongson Province, Thailand, 9 May 2003. UNMF 00567 (2) 67.6–68.25 mm SL, Huai Maelamao, Tak Province, Thailand, 13 February 2004. UNMF 00579 (1) 68.45 mm SL, Lang River, tributary of Pai River, Pangmapha district, Maehongson Province, Thailand, 17 February 2005; UNMF 00568 (3) 83.63–94.1 mm SL, Maehongson Province, Thailand, 2004. UNMF 00569 (8) 64.75–98.9 mm SL, Kasa River, the border between Sangklaburi district, Kanchanaburi Province, Thailand and Myanmar, Myanmar, October 2002. UNMF 00570 (2) 103.6–106.6 mm SL, same locality as UNMF 00569. October 2002. UNMF 00571 (1) 88.85 mm SL, Suriya River, Jakae, Laivo, Sangklaburi District, Kanchanaburi Province, Thailand, April 2006, specimen collected by fishermen. UNMF 00566 (3) 65.28–73.75 mm SL, bridge across Pai River in Pai District, Maehongson Province, Thailand.

Barilius caudiocellatus: KIZ 748230–748235, 748237–748240, 197400916–197400917 (12), 61.45–77.8 mm SL, syntypes, Mengding (23°33'N, 99°05'E) belonging to Salween drainage, Yunnan, China, 1974.

Barilius barila: RLIKU 1391 (1) 70.4 mm SL, Gowahati, Assam, India, 8 April 1998, P. Musikasinthorn.

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